

Mechanical and Electrical Conductivity Studies of PANI-PVA and PANI-PEO Blends

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Abstract-Poly aniline (PANI) separately blended with polyvinyl alcohol (PVA) and Polyethylene oxide (PEO) has been prepared by solution cast method using N-Methyl Pyrrolidone (NMP) as common solvent. The structural changes of PANI-PVA and PANI-PEO films were studied by XRD and FTIR techniques. XRD and FTIR studies confirmed the complex formation in polymer blends. The change in the intensities in the polymer blend and appearance of new peaks in the FTIR spectra revealed the blending of poly aniline with PVA and PEO. The physical properties of these polymer blends were analyzed by tensile testing and scanning electron microscopy (SEM). SEM studies revealed the change in surface morphology of pure PANI with blending. From tensile testing, it was observed that PANI-PVA blend is the most promising composition for several industrial applications. The dc conductivity of these polymer blends has been determined in the temperature range 300K to 373K. The dc conductivity of pure PANI is found to be more than PANI-PVA and PANI-PEO blends. The change in the conductivity of this polymer blending at different temperatures depends on intra-chain and inters-chain mobility and are explained by two phase model.

Keywords-Poly aniline, Polymer blend, Dc conductivity

I. INTRODUCTION

Conducting polymers have recently become an area of wide-spread interest in organic electronics due to their potential application in energy conversion systems such as photovoltaic cells, solar cells, bio sensors etc [1-3]. In view of this, a great deal of interest has been paid to the transport, mechanical, optical and conducting properties of polymers. Amongst conducting polymers poly aniline (PANI) receives greater attention due to its environmental stability, ease of fabrication and the possibility to blend it with thermo plastics. Poly aniline refers to a class of polymers which in the base (none conducting) form is preferred polymer system for many applications [4-5]. However, two major limitations of conducting poly aniline are an inability to process it by conventional methods and its poor mechanical properties. These limitations can be overcome by preparing conducting poly aniline blends and composites which possess the mechanical properties of the insulating host matrix and the electrical properties of the conducting poly aniline guest. When the host is a polymer, the resulting system is termed a poly aniline blend (or composite), but when the host is a non-polymer material (e.g. metal oxides, silica), it is invariably referred to as a composite. Conducting poly aniline blends are a novel class of materials for which the threshold for the onset of electrical conductivity can be reduced to volume fractions well below that required for classical percolation, which is 16% by volume for a conducting material dispersed in an insulating matrix in three dimensions. Due to a low percolation threshold and a continuous increase in conductivity, $j(f)$, for volume

fractions (f) above the threshold, conducting poly aniline blends can be reproducibly fabricated with controlled levels of electrical conductivity while retaining the desired mechanical properties of the polymer matrix [6]. These blends have potential applications in electromagnetic shielding, electricity dissipation, conducting glues and sensor materials [7-11]. A blend is a mixture of two or more polymers. Blending opens up a route for a combination of different properties. Some recent results indicate that conducting polymer composite materials may have significantly improved electronic and mechanical properties as compared to pure conducting polymer films, making the composite more suitable for microelectronic applications. Already much of the research done in this field, it had been evident that the intrinsic properties of the components of the blends were changed.

II. EXPERIMENTS

Blends of PANI (emeraldine base, Elche mop, India) with PEO (Aldrich), PVA (Loba Chemie) were prepared by solution cast technique using N-Methyl Pyrrolidone (NMP) as a common solvent. Pure PANI was initially taken in NMP solution and stirred for 2 hrs. Then the copolymer such as PEO, PVA was added in equal amount to this mixture and stirred again for nearly 12 hrs. Then this homogeneous mixture was filtered, poured in a glass dish and kept in an oven maintained at 60°C to get slowly evaporated. The final product was vacuum dried thoroughly at 10^{-3} Torr. In this manner film of pure PANI, PANI+PEO, PANI+PVA were prepared.

The XRD studies of these samples were carried out with the help of PHILIPS PW 3710 Diffract meter in the range 10^0 - 80^0 . The FTIR spectra of these samples have been recorded with the help of JASCO FTIR-5300 Spectrophotometer in the range 400-4000 cm^{-1} with resolution of 2 cm^{-1} . The mechanical strength of these polymers has been estimated using micro tensile testing machine. The surface morphology of these polymer blends were studied by scanning electron microscopy (SEM) instrument with gold sputtered coated films. The dc conductivity measurements of these polymer blends was measured in the temperature range from 300 – 400 K using two probe method.

III. RESULTS AND DISCUSSIONS

The X-Ray diffraction pattern for pure PANI, PANI+PVA and PANI+PEO films are shown in Figure 1.1 and 1.2. The diffraction pattern of pure PANI and PVA indicates the amorphous nature while that of PEO showed semi crystalline nature. The diffraction pattern of pure PANI has a broad peak around $2\theta = 23.44^0$ which is a characteristic peak of PANI [12]. The characteristic peak of PANI has been shifted slightly

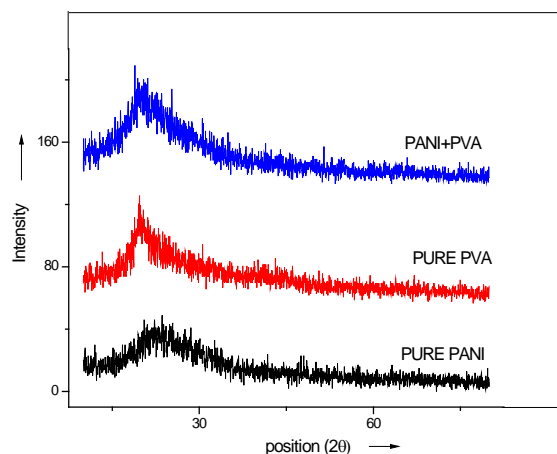


Figure 1.1

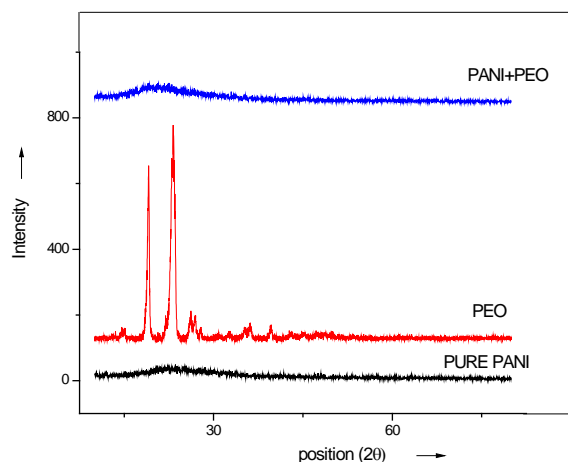


Figure 1.2

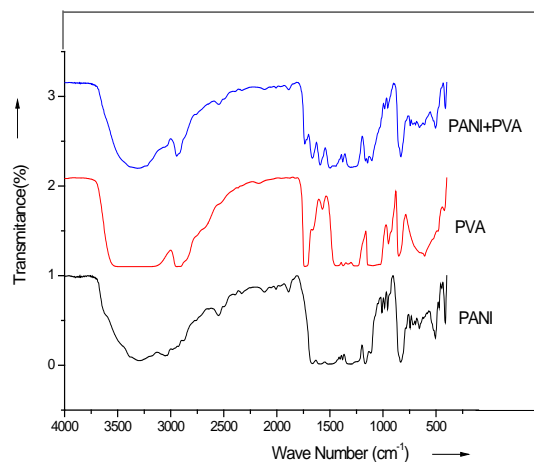


Figure 2.1

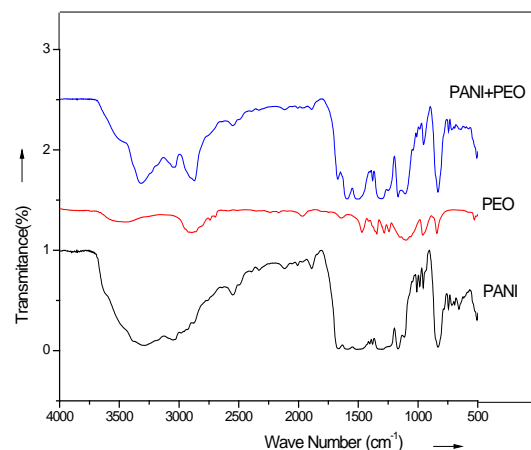


Figure 2.2

Table I OBSERVED CHARACTERISTIC VIBRATIONS FROM FTIR

Characteristic vibration	References	PANI	PVA	PEO	PANI+PVA	PANI+PEO
N-H stretching	3450	3306.64			3318.16	3318
Aromatic C-H stretching	2925	3006.81			2934.19	3037
C-N stretching	1560	1568.99			1610.51	
Aliphatic C-H stretching (PEO)	2897.1			2889.26		2868
C-O stretching (PEO)	1095.2			1076.6		1113.7
O-H stretching (PVA)	3300		3565.5		3356.04	
C-H stretching (PVA)	2930		2921.6		2925.25	

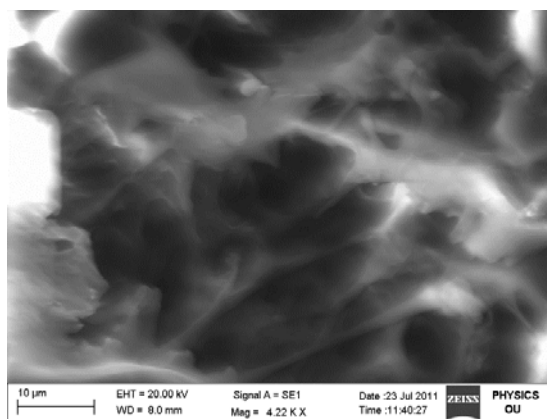
in PANI blends as shown in figures. The XRD pattern of these polymer blends does not show sharp peaks which confirm the amorphous nature of polymer blends. [13-14]

The FTIR spectra of pure PANI and PANI blends are shown in Figure 2.1 and 2.2. From FTIR data it is clear that new peaks corresponding to PVA and PEO are observed in the blended poly aniline. The appearance of new peaks along with changes in existing peaks directly indicates the blend formation. The positions and observed characteristic bands are tabulated in Table 1. The obtained values are in good agreement with theoretical prediction

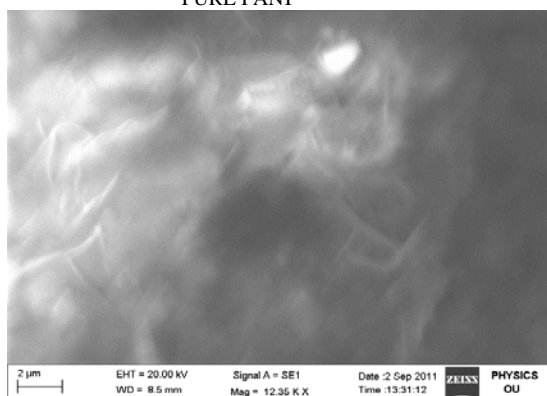
The surface morphology of PANI and PANI blended with PVA and PEO were studied using SEM technique. The micrographs of the blended films are presented in Figure 3. In the SEM figures it was observed that PANI grains are embedded in the co-polymer matrix.

The mechanical properties in the blended films are compared with pure PANI by using micro tensile testing machine. The stress – strain curves of the polymer blends obtained and the values of Young's modulus are tabulated in the Table 2. The stress-strain data clearly indicates that PANI

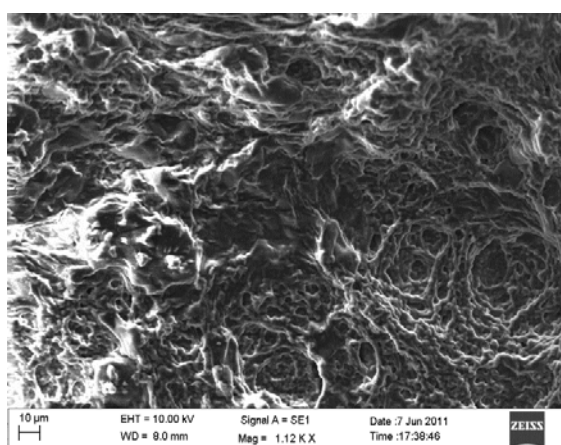
+ PVA polymer blend more flexible than pure PANI and PANI + PEO blend.



PURE PANI



PANI+PVA



PANI+PEO

Figure3. SEM micrographs of polymer blends

TableII

Polymer	Young's modulus
PANI	0.17
PANI+PVA	0.89
PANI+PEO	3.71

The temperature dependence conductivity of Pure PANI, PANI +PVA and PANI+PEO films is presented in Figure 4. The over-all mobility of charge carriers in conducting polymer

blends depends on inter-chain mobility and intra-chain mobility. In PANI-based polymer blends two stages of percolation threshold may be observed, with one corresponding to the well blended phase and the other to the separated phase [15]. The Dc conductivity data suggests that the conductivity of PANI+PEO blend is due to the hopping mechanism between Ether group of PEO and conducting poly aniline. The low conductivity of these polymer blends when compared with pure PANI could be a direct effect of molecular electronic features which improved the degree of crystalline nature but not the conductivity [16]. The conductivity in these blends may be enhanced by doping laterally linked rich donor acceptor groups. Further studies are in progress.

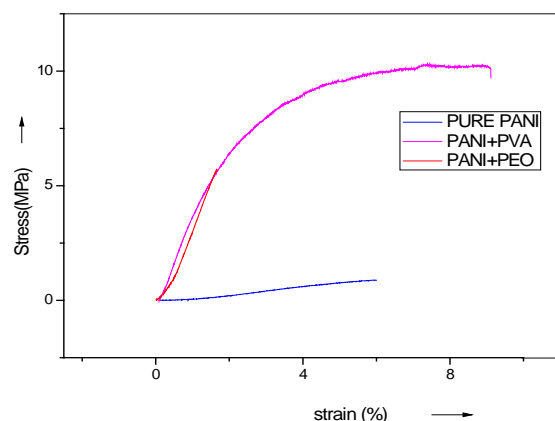


Figure4. Mechanical behavior of polymer blends

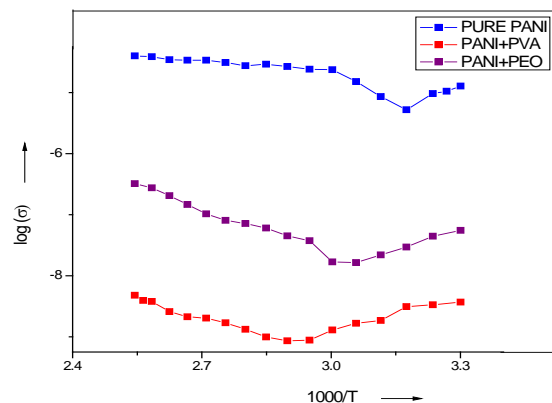


Figure5. Dc conductivity of polymer blends

IV. CONCLUSIONS

In the present work Pure PANI and its blends with PVA, PEO were prepared by solution cast method. The blends were characterized by XRD, FTIR and SEM techniques. It is found that the conductivity of pure PANI is more than PANI blends. The blends were prepared in order to combine the mechanical properties of PVA, PEO with conducting properties of PANI.

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